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June, 1907 **Entomological Series** **Vol. I, No. 3**

Memoirs of the Department of Agriculture in India

THE INDIAN SURFACE CATERPILLARS OF THE GENUS AGROTIS

BY

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AGRICULTURAL RESEARCH INSTITUTE, PUSA

PRINTED BY THACKER, SPINK & CO., CALCUTTA

Price, Re. 1-8

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INTRODUCTION.

A word of explanation is desirable as to the joint responsibility for this Memoir. Mr. C. C. Ghosh is in charge of the Pusa insectary and made the detailed study of the life of the insect which occupies pages 260—272. His account is given in full with only small additions. The remainder of the Memoir is my own, with the additions noted under their authors' names.

PUSA,
Dated February, 1907.

H. MAXWELL-LEFROY,
Imperial Entomologist.

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DESCRIPTION.

THE genus *Agrotis* as it stands in Hampson's Fauna of India, Moths, Volume II, has been revised in the same author's catalogue of Lepidoptera Phalænæ, now in course of publication, and has been scattered among several genera. Of the recorded Indian species, four only are widespread in the plains of India, and have some economic importance. *Agrotis ypsilon*, Rott, is the commonest Surface Caterpillar (cutworm) of India; *Agrotis flammatra*, Schiff, is occasionally an extraordinarily abundant insect. *Euxoa* (Agrotis) *segetis*, Schiff, and *E. spinifera*, Hubn., are also common, and since their life-history seems to be very close to that of *Agrotis*, may be included in this paper. The description of each species as it occurs in Hampson's Catalogue of Lepidoptera Phalænæ is reprinted here for reference; the species are also figured in Plate I.

EUXOA SPINIFERA—*Hubn.*

Male.—Head and thorax grey-white mixed with pale brown and a few black scales; palpi blackish at sides except at extremity; tegulæ with dark medial line; tarsi black, ringed with white; abdomen white, dorsally tinged with ochreous. Fore-

wing pale ochreous with a violaceous tinge and slight fuscous suffusion, especially on costal area ; the veins slightly streaked with fuscous ; an indistinct double subbasal line from costa to submedian fold ; the antemedial line represented by oblique double striæ from costa and a slightly curved line from median nervure to vein 1 ; the claviform very elongate lanceolate, strongly defined by black and filled in by dark brown ; the orbicular and reniform with fuscous centres and ochreous annuli defined by black, the former elliptical and with its outer edge produced to a point, often open above, the latter often angled inwards on median nervure, a black fascia between them in cell and slight streaks from outer edge of reniform ; the postmedial line hardly traceable, dentate, bent outwards below costa, excurved to vein 4, then incurved ; the subterminal line pale, dentate to termen on veins 7, 4, 3, with dentate black marks on its inner side at middle, and the area beyond it blackish except towards apex and tornus ; a terminal series of black points. Hindwing semihyaline white, the costal area suffused with ochreous, a fine terminal line on costal half.

Female.—Usually darker ; hindwing with the veins, costal and terminal areas tinged with fuscous.

Expanse 26—40 mm.

Euxoa segetis—*Schiff.*

Male.—Head and thorax pale brownish ochreous slightly irrorated with black, palpi brown at sides, antennæ brown, tarsi banded with fuscous ; abdomen whitish, tinged with brown. Forewing pale brownish ochreous striated with brown, a double fuscous subbasal line from costa to submedian fold interrupted at cell ; a double waved antemedial line, the outer stronger ; claviform elongate, usually small, outlined with black ; orbicular and reniform defined by black and with brownish centres, the former small or large, round or somewhat elliptical, the latter usually well developed ; an oblique medial shade from lower angle of cell to inner margin ; the postmedial line dentate, bent outwards below costa, excurved to vein 4, then oblique ; the subterminal

line indistinct, pale, defined by brown on inner side, angled outwards at vein 7, and excurved at middle ; a terminal series of black points. Hindwing semihyaline white, the veins, costa, inner margin, and termen tinged with brown ; the underside with the costal area irrorated with brown and crossed by a postmedial striga. Specimens are often tinged with reddish brown or fuscous.

Female.—Nearly always darker and suffused with reddish brown or fuscous ; forewings sometimes fuscous black, the markings obscured.

Expanse 30—46 mm.

AGROTIS FLAMMATRA—*Schiff.*

Head and thorax grey-brown, tinged with purplish red ; palpi dark brown at sides except at tips ; tegulæ with semicircular black brown patch ; tarsi with pale rings to the joints ; abdomen pale grey-brown. Forewing grey-brown tinged with purplish red ; the costal area usually pale to middle or postmedial line ; the subbasal line represented by slight double striæ from costa ; a black streak in base of submedian fold, expanding beyond the subbasal line ; the antemedial line double, waved, almost obsolete on costal area ; claviform with its extremity slightly defined by black ; orbicular and reniform brownish-grey, the former rounded, open above, defined by black below, the latter defined by black on inner side, or with the cell black before the orbicular and sometimes also between the stigmata ; the postmedial line minutely dentate, slightly defined by ochreous on outer side, bent outwards below costa, excurved to vein 4, then incurved and slightly angled outwards on vein 1 ; the subterminal line greyish, often defined by slight dentate black marks on inner side, angled outwards at vein 7, and slightly dentate at veins 4 and 3 ; traces of a terminal series of black points and a fine ochreous line at the base of cilia. Hindwing ochreous whitish suffused with pale brown ; the cilia white, with a brown line at base ; the underside whitish, the costal area irrorated with brown, a slight discoidal lunule and sinuous postmedial line.

Expanse 40—60 mm.

AGROTIS YPSILON—*Rott.*

Head and thorax red-brown, the latter suffused with fuscous; frons with blackish bar above; back of head with two black spots; tegulæ with brown and black medial band; pectus whitish; tibiæ and tarsi ochreous white and black; abdomen grey-brown. Forewing ochreous irrorated with brown; the costal area suffused with fuscous brown, and often the whole wing to the postmedial line; a double, waved, subbasal line from costa to the submedian fold, a double, waved, antemedial line, dentate inwards on median nervure and vein 1 and outwards above inner margin; claviform moderate or small, defined by black; orbicular and reniform defined by black and fuscous centres, the former small, elliptical, or with its outer edge produced to a point, the latter with wedge-shaped black spot from its outer edge; an indistinct dentate medial line; a double minutely dentate postmedial line produced to points on the veins, bent outwards below costa, excurved to vein 4, then incurved; a subterminal series of pale and black dentate marks, those above veins 4, 5, with the black on their inner side stronger and some fuscous suffusion on the outer; the veins towards termen with dark streaks; a terminal series of points. Hindwing semihyaline white, the veins, costal and inner areas, the termen tinged with brown strongly, strongly in female and in the New Zealand form.

Expanse 40—50 mm.

2. EUXOA SPINIFERA—*Hubn.*

A list of synonyms will be found in Hampson's Catalogue of Lepidoptera Phalænæ, Vol. IV, p. 177. The original description is given in Hubner's Sammlung Europæischer Schmetterlinger, Noctuidæ, Fig. 389 (1827). The species figures as *Agrotis biconica*, Koll, in the Fauna of India, and also in Indian Museum Notes, and this is practically the only synonym necessary to the Indian student. Hampson records it from a long list of localities covering South Europe, Egypt, the East and South portions of Africa, Syria, Persia, Kashmir, the Himalayas, the plains of

India, Ceylon, Burma. There is a single reference to it in Indian Museum Notes, Vol. IV, p. 195, where it is stated to have been reared from a batch of caterpillars which were received in March 1897, from Messrs. Finlay, Muir & Co. as attacking indigo plants in Tirhut. There appear to be no further references to its destructiveness in India, and it has only once been definitely reported as a pest since this last reference. Specimens were received from the Deputy Commissioner of Gujrat, Punjab, with a report that the caterpillars were attacking young cotton plants. A single specimen of the moth was reared from a batch of Surface Caterpillars found on gram in Pusa in November 1906, the remainder being *Agrotis ypsilon.*

The distribution recorded for the species by Hampson and by the Indian Museum Collections shows it not to be a common species in the plains of India, but rather a hill species found but rarely outside hill localities. Actually it is apparently one of those insects which is normally an ordinary member of the insect fauna, known only to insect collectors, but which occasionally becomes abundant enough to attack crops sufficiently to become noticeable. The larvæ received from Gujrat were similar to those of *Agrotis ypsilon* described below, but more brown in colour. They were sent in May, and moths emerged at varying dates during June. The species was also reared from caterpillars found at the roots of plants, and it is probable that the larva could be readily found widely in India if searched for in weedy land or land on which low growing plants were growing.

3. Euxoa segetis—*Schiff.*

The description is (Wien. Verz., pp. 81, 252, 776) under the genus *Noctua.* Hampson in Fauna of India, Moths, Vol. II, p. 181, refers to it under *Agrotis* and in Catalogue of Phalænæ, Vol. IV, p. 167, gives a list of synonyms, none of which are necessary for the literature of this species in India. The distribution is wide, covering Europe, East and South Africa, Japan, China, Afghanistan, Kashmir, the Himalayas and hill localities

in India. There are two references to it in Indian Museum Notes. In Vol. II, p. 6, the moth is recorded as one of two reared from caterpillars which ringed young coffee plants in Mysore in January ; it was stated that over 110,000 had been destroyed by handpicking. The second reference is in Vol. V, p. 145, covering a reference in Vol. IV, p. 194 ; in this case, caterpillars had been sent in from Tirhut as destructive to indigo in March 1897 ; in the same year, another Behar planter reported "caterpillar," and in 1901 Mr. L. de Nicéville visited Behar to investigate "caterpillar" ; it is now certain that the "caterpillar" referred to was not *Euxoa segetis* but *Caradrina exigua*, and it is to this latter insect that the remaining information in Vol. V of Indian Museum Notes refers. We have then no information beyond the isolated fact of the occurrence of this insect in Behar feeding on young indigo plants. Amongst the many injurious insects bred in the Central Provinces, this species occurred once on cabbage at Nagpur (Ratiram Khamparia). The insect has not been reported as a pest since 1901, but is very likely to be found as a surface caterpillar in any hill locality. Meyrick (Handbook of Lepidoptera) states that the larva occurs in England from July to April, the imago from June to August ; the larva feeds on the roots of a variety of plants. For the Indian student the species may be classed as one which may possibly be found at any time, but is unlikely to occur as a pest in the cultivated plains. It will be distinguishable only as a moth, and will be confused with *Caradrina* unless carefully examined.

4. Agrotis Flammatra—*Schiff.*

This species was described in 1776 (Wien. Verz., p. 80), and by Hampson on p. 189 of the second volume of the Fauna of India, Moths, and on p. 393 of the fourth volume of the Catalogue of Lepidoptera Phalænæ. It is referred to once in Indian Museum Notes under the generic name *Ochropleura*. Its distribution covers Europe, Syria, Persia, W. Siberia, Kashmir, the Himalayas, and some places in the plains of India. The single reference to it in Indian Museum Notes states that it was injuring

opium plants (with *Agrotis ypsilon*) in Oudh in March 1890. In March 1905, the moths were extremely abundant at Pusa (Bengal), literally thousands coming out in the dusk to fly about the trees and also coming to lights. For a few days this extraordinary phenomenon lasted, the moths hiding by day in corners and shady places, coming out in the evening and crowding in the trees where they fed on the nectar of the flowers of sissoo (*Dalbergia sissu*). If these moths had laid eggs in the crops, not a plant would have escaped, but no injury was done to the crops nor have the moths been abundant since that time. They were found in small numbers in March 1906 and at no other time. Larvæ have been searched for and found commonly at the roots of grasses and at the roots of tobacco, in neither case being destructive. Hampson states the larva to be uniform green with pale spiracular stripes; Pusa larvæ were dull green like a rather green *Agrotis ypsilon* larva. This species has not been reared as a pest, nor has it been sent in during the past few years; it may, however, be regarded as a potential pest, which may at any time occur seriously. A curious feature of the insect is its occurrence as an imago in thatched roofs; apparently it hibernates there as an imago and is found abundantly during the cold weather, emerging in March.

5. Agrotis ypsilon—*Rott.*

A full description, with references to the original description (Naturf. IX, p. 141, 1776), and synonyms, is given by Hampson on p. 368 of Vol. IV of Catalogue of Lepidoptera Phalænæ. The most important synonym is *Agrotis suffusa* of Schiff and Fabr., under which name it is referred to in Indian Museum Notes and other Indian publications, which got their information from this source. The distribution is almost universal; North and South America, Europe, N. Africa, Syria, Japan, China, Tibet, Kashmir, the Himalayas, Ceylon, Java, Australia, New Zealand and Hawaii are included. In India proper, the distribution is, so far as is known, peculiar; the species is recorded from localities in the Himalayas, from localities in Behar and Oudh, and from

districts in Northern Bengal and Assam—always from localities near the Himalayas ; no specimens seem to have been reared or collected in Madras, the Central Provinces, Central India, Bombay or the Western Punjab. Whether this distribution is due to the nature of the soil being suitable only in certain tracts, or to the climate, or to the insect not having spread further, cannot be ascertained. It may not even be limited to the areas mentioned, but must at least be far commoner there than elsewhere.

6. Life History.

The life cycle of the Greasy Surface Caterpillar or Cutworm (*A. ypsilon*) as illustrated by two specially noticed, is shown below :—

Eggs laid.	Eggs hatched.	Larva pupated.	Moths emerged.
28th January.	6th February.	11th March.	29th March.
7th March.	12th March.	10th April.	22nd April.
7th „	12th „	11th „	22nd „

The period varies a great deal in summer and winter ; in summer the life cycle may be completed in about half the time taken in winter. As will be seen later on, the egg stage varies from about two days in summer to about seven or eight days in winter ; the larval stage may vary from about 25 days to more than 35 days ; and the pupal stage varies from about 10 to 28 days.

Egg.—The egg is domeshaped, about ½ mm. wide from side to side, and creamy white in colour. There is a small circular depression at the top and from its periphery ridges run down the sides to the basal circumference. During the day the moths remain hiding in dark corners and cracks. They are also seen to sit close to the ground near the stems of plants. Their legs and wings are held close to the body, and on being touched they sometimes feign death. When disturbed they shoot out and try to secure another dark corner or hiding place by a sort of jerky motion which is not flying. But at night when they alight or walk upon the ground, the wings do not remain closely applied to the body but in a horizontal position, and the body is as much above the ground as the legs can raise it. They come out of their

hiding places as soon as it is dusk and fly about until complete darkness sets in. Oviposition commences some time after this, and continues up to a late hour. The eggs laid by a moth up to 8 p.m. in a winter night were noticed; but the next morning nearly twice as many eggs more were found to have been laid during the night.

It has been found by supplying shoots of plants which the insects were damaging at the time, that the moths prefer to lay eggs on gram, poppy and tobacco. Eggs are laid generally on leaves and parts of stems which are near the ground. The abdomen is curved downwards and so bent that the egg is deposited on the sides of leaves or stems, almost opposite to that on which the moth takes its position. It is due to this fact that the majority of eggs come to be laid on the underside of leaves and stems. From one to about thirty eggs may be laid at one place, and when laid together, they are juxtaposed and touch one another. During the time oviposition continues, the moth may be seen to walk, with its wings in a horizontal position, from place to place over the ground. In the insectary, at intervals, it came to drink food. The food supplied was sugared water to which was added a drop of vinegar.

Three or four moths used to be put together in a cage and separated on the day after eggs had been laid for the first time. In this way the oviposition record of three separate moths has been found out. The following table shows the number of eggs a moth can lay, for how many days it can continue to lay eggs and how many eggs it can lay in all. The first two moths were fed only twice and the third moth was fed regularly every day.

	Oviposition commenced.	Eggs on 1st day.	Eggs on 2nd day.	Eggs on 3rd day.	Eggs on 4th day.	Eggs on 5th day.	Eggs on 6th day.	Eggs on 7th day.	Eggs on 8th day.	Eggs on 9th day.	Eggs on 10th day.	Eggs on 11th day.	Total.
1	28th January ...	19	38	79	19	67	..	...	...	...	...	...	222
2	,, ,, ...	9	10	9	6	59	44	62	...	...	...	...	199
3	15th March ...	25	...	14	39	40	59	25	17	37	53	35	344

From the above statement it will be seen that a moth can lay up to 79 eggs in a single day, that egg-laying may continue for eleven days, and that a single moth can lay up to 344 eggs. But there is reason to believe that a moth which moves about freely and which in its larval stage has fed freely, can lay a larger number of eggs. No egg was laid on the day before death. The eggs of the first two moths did not hatch owing to being placed in unfavourable conditions, but all of the 344 eggs of the third moth hatched.

The colour of the egg undergoes some change after a period varying from about 12 hours in summer to about 3 days in winter. The depression at the top becomes brown and a broad brown belt appears on the side halfway from the top. The general colour is dull. Some time before hatching a black spot appears at the top marking the position of the head within. The larva eats out a hole in the shell and after it comes out through this hole, it feeds first on the shell. The shell may be wholly eaten or a portion of it left.

Below is shown the duration of the egg-stage, which varies from about 2 days in summer to about 8 or 9 days in winter.

Eggs laid.	Eggs hatched.	Duration.
28th January (night) ...	5th February (night) ...	About 8 days.
5th March (night)	12th March (morning) ...	,, 6½ ,,
7th ,, ,, ...	,, ,, (night) ...	,, 5 ,,
8th ,, ,, ...	13th ,, (noon) ...	,, 4½ ,,
17th ,, ,, ...	23rd ,, ,, ...	,, 5½ ,,
19th ,, ,, ...	Some on 21st March (noon) ..	,, 1½ to 5 days.
	Rest on 24th March (night) ...	
23rd ,, ,, ...	27th March (night) ...	,, 4 days.
24th ,, ,, ...	Some on 26th March (night) ...	,, 2 to 3 days.
	Rest on 27th March ,, ...	
25th ,, ,, ...	Some on 27th March (morning)	,, 1½ days.

Removal from the plant has no effect upon the eggs. Some of the eggs laid on the 5th March were kept in a glass pot

covered with a ground-glass covering. They hatched almost at the same time as those left on the plant.

The effect of the sun on the eggs is not perceptible. Eggs laid on the 8th March, and kept always exposed to the sun from the beginning, hatched on the 13th; while those laid on the 7th and kept always in the shade, hatched on the 12th, *i.e.*, after the same number of days.

The effect of submergence in water also is not appreciable, so long as the leaves or stems on which the eggs are deposited, do not rot. Its effect may be to prolong the egg-stage for some time. A branch of the plant, the eggs on which were kept exposed to the sun, was so managed from the beginning that the eggs on it remained part of the day under water and the rest of it in moist earth. They hatched about 30 hours after those exposed to the sun had hatched. Some of the eggs laid on the 7th March were kept under water in a pot for about three hours, and they hatched at the same time as those left on the plant. Again, some eggs laid on the 25th March were kept under water in a pot for about 16 hours; these did not hatch, but some of the eggs showed no external change. The rotting of the leaves on which they were deposited had probably something to do with their failure to hatch.

Larva.—The larva just hatched is about $1\frac{1}{2}$ mm. long, its head is shiny black, the prothorax bears a small black shield, the body is cylindrical, the general colour is slightly yellowish gray. The first two pairs of prolegs are not well developed; therefore the larva has a gait somewhat like that of a semilooper, *i.e.*, in locomotion a hump appears near the middle of the body. The young larvæ, like the full-grown ones, have the habit of coiling up at the slightest touch or breath of wind, so that when they are engaged, after emergence, in the eating of the eggshells, the slightest shaking of the plant or the softest breeze causes all of them to fall to the ground. They do not or cannot climb the plants to get at the leaves for food. Their food habit is remarkable in this way that they can eat and live upon even the old yellow leaves as long as they are soft. The young larvæ, therefore,

feed upon fallen leaves and leaves of those branches which happen to lie on the ground. They do not make holes in the earth but generally live hidden under the leaves which they eat. They do not show the cannibalistic habit of the advanced larvæ.

The newly hatched larva is slightly yellowish gray in colour. After about 24 hours, the thorax becomes light green and minute black points appear scattered over the body, distinctly visible through the lens. After about one day more a portion behind the head becomes whitish, behind this a portion becomes light green, and the rest of the body is yellowish. Again, there is a change, and the colour becomes uniform pale orange yellow. Then after the first moult the colour is yellowish with a greenish tinge, and a thin median line appears on the dorsum. After the second moult the characteristic markings of the full-grown larva are perceptible ; the general colour becomes dark and in successive moults it becomes darker.

In the insectary the caterpillars have been fed with leaves of poppy, gram, lucerne, celery, clover, mangold, tobacco, sunflower, cotton, bean, cabbage, radish, mustard, brinjal, potato, plantain, and several weeds including grass. They can live upon all these kinds of leaf, and thus never run the risk of dying of starvation. Among the above plants, they prefer poppy to all the rest, and next to that, gram, tobacco, brinjal, mustard and radish. Poppy seems to be a very nourishing food for them and develops them quickly. Some of the larvæ which hatched on the 12th March were exclusively fed with poppy, and the others with gram, and only occasionally with celery and lucerne. On the 31st, those feeding on poppy measured from about 34 to 42 mm., while those on gram measured from about 20 to 28 mm. This difference in growth, due to poppy and gram, was also noticed in the case of the first two larvæ, which were being specially watched for moults. For some time after hatching both of them were fed with gram, but afterwards poppy was given to the first, and gram was continued for the second. At the end, however, all are seen to be equally developed, but those which grow quicker pupate earlier.

Four larvæ were specially watched to see how many moults they cast. In the following statement will be found the number of moults, the period of each instar and growth in successive instars :—

	Hatched.	1st moult and length after moult.	2nd moult and length after moult.	3rd moult and length after moult.	4th moult and length after moult.	th moult and length after moult.	6th moult and length after moult.	7th moult.
1	12th March	18th Mar. 4 mm.	22nd Mar. 6 mm.	25th Mar. 12 mm.	28th Mar. 19 mm.	2nd Apr. 38 mm.	10th Apr. (pupated.)	
2	,, ,,	18th Mar. 4 mm.	22nd Mar. 6 mm.	24th Mar. 8 mm.	27th Mar. 15 mm.	29th Mar. 21 mm.	4th Apr. 35 mm.	11th April. (pupated.)
3	6th February	13th Feb.	18th Feb.	22nd Feb.	27th Feb.	3rd Mar.	11th Mar. (pupated.)	
4	,, ,,	,, ,,	,, ,,	23rd ,,	,, ,,	,, ,,	11th Mar. (pupated.)	

The full-grown larvæ attain a length of about 42 mm. to 45 mm. at the time when they begin to rest before pupation. Out of the 4 larvæ watched: 3 pupated at the 6th and 1 at the 7th moult. Before each moult the larva rests for some time and, as will be seen later on, takes no food. While it rests, the prothorax is a little prolonged, forming a sort of a neck behind the head. In all the moults except the last one at which the larva turns into the chrysalis, the moult of the head is cast separately by rubbing the head against any surface. When the skin is being shed, the larva does not appear to be very uncomfortable, as it can move about while the skin slips slowly towards the hind end. Just after the moult the head is soft and somewhat creamy white; the body also is not so dark as is seen normally. It is strange that eating the cast skin is not a general habit among the cutworm larvæ, which are so much addicted to cannibalism; cast-off skins are rarely eaten. The full-grown larva is a dark-coloured, sometimes dark-brown, plump-bodied caterpillar and measures about 44 mm. or $1\frac{3}{4}$ inches. Its average daily growth is, therefore, about $1\frac{1}{2}$ mm. The head is shiny, slightly reddish black and compressed dorsoventrally and bears an inverted V-shaped mark. The prothorax bears a slightly

reddish black shield. On the upper part of the dorsum there is a broad longitudinal whitish space traversed by the more or less interrupted median line. The rest of the upper side of the body is dark or blackish. The ventral colour is muddy gray. The five pairs of prolegs are thick, fleshy. At rest as well as in locomotion, the ventral surface of the body always touches the ground. On being touched the larva coils in the form of a disc.

The young larvæ eat the epidermis of the leaves that are available on the ground and are generally found to live hidden under those leaves. As they grow, their habit changes. They live in cracks or holes which they make in the ground, and very seldom come out during the day, although occasionally one may be found to walk from one place to another. They are active principally at night, and fell the plants by cutting their stems either below the surface of the ground or above the ground, thus getting plenty of leaves on the ground. Cut branches are sometimes seen to be dragged into the holes, where the leaves are eaten at leisure. Cabbages are bored from below and the larvæ may be found in the bore.

The feeding habits of a larva are best illustrated by the amount of food it eats daily. Two larvæ were kept separately. A weighed quantity of green food used to be supplied to each. The next day the quantity of food left was weighed and the quantity eaten was found out. To get at a more correct result, the same quantity of the green stuff supplied as food was separately kept in a similar manner and weighed the next day at the same time in order to find out the loss in its weight by evaporation. The weights of food eaten in the following statements are calculated by taking this loss into consideration, the lost weight being in every case wholly deducted. The weights of food eaten should be taken as approximate, when the larva ate much after the 4th moult and specially in the last instar, it did not wait so long as to let the food lose as much by evaporation as is actually deducted. In the beginning also it may have eaten more or less than what is given in the statement. The weights of the larva and of the excrements are given as they were found every day.

The newly-hatched larva weighs less than ·01 grain. In the beginning it eats so little that the amount cannot be easily determined by weighing. The weights were taken after it began to eat to an appreciable extent.

First Larva.

Date.	Food eaten in grains.	Weight of larva in grains.	Excrements in grains.	Remarks.
28th January	.....	.....	.....	Egg laid.
6th February	.....	·01	.....	Egg hatched.
13th ,,	.....	·02	.....	First moult.
18th ,,	·1	·05	·02	Weight of excrements up to date. Second moult.
19th ,,	·2	·06	·01	
20th ,,	·3	·1	·03	
21st ,,	·2	·16	·01	
22nd ,,	·2	·19	·01	Third moult.
23rd ,,	·5	·3	·03	
24th ,,	·6	·57	·08	
25th ,,	·6	·85	·12	
26th ,,	·1	·85	·02	
27th ,,	1·1	1·4	·1	Fourth moult.
28th ,,	1·6	2·66	·4	
1st March	2·5	4·1	·6	
2nd ,,	·2	3·9	·08	
3rd ,,	·7	4·65	·2	Fifth moult.
4th ,,	4·6	8·2	·8	
5th ,,	6·7	12·7	1·7	
6th ,,	8·6	16·9	3·4	
7th ,,	6·2	18·4	3·3	
8th ,,	.....	15·1	1·4	
9th ,,	.....	8·4	.....	
10th ,,	.....	8	.....	
11th ,,	.....	7·75	.....	Pupated; weight of pupa.
19th ,,	.....	7·7	.....	
29th ,,	.....	4·2	.....	Moth emerged; weight of moth.

Second Larva.

Date.	Food eaten in grains.	Weight of larva in grains.	Excrements in grains.	Remarks.
28th January	.....	.....	.....	Egg laid.
6th February	.....	·01	.....	Egg hatched.
13th ,,	.....	·02	.....	First moult.
18th ,,	·1	·05	·02	Excrements up to date. Second moult.
19th ,,	·2	·06	·01	
20th ,,	·2	·1	·02	
21st ,,	·4	·17	·03	
22nd ,,	·1	·17	·01	
23rd ,,	·3	·23	·02	Third moult.
24th ,,	·2	·46	·07	
25th ,,	·6	·93	·15	

SECOND LARVA.—(*Concld.*)

Date.	Food eaten in grains.	Weight of larva in in grains.	Excrements in grains.	REMARKS.
26th February	·0	·85	·04	
27th ,, ...	·8	1·25	·1	Fourth moult.
28th ,, ...	1·5	2·25	·26	
1st March	2·3	3·8	·7	
2nd ,, ...	·1	3·6	·1	
3rd ,, ...	1·1	4·35	·1	Fifth moult.
4th ,, ...	4·5	8·1	·9	
5th ,, ...	6·1	12·9	1·5	
6th ,, ...	7·7	17·3	3·0	
7th ,, ...	5·7	18·6	3·5	
8th ,, ...	·1	14·9	·2	
9th ,, ...	... ...	8·2	.....	
10th ,, ...	.....	7·6	.....	
11th ,, ...	.....	7·4	... ...	Pupated; weight of pupa.
12th ,, ...	.....	7·3	.....	
29th ,, ...	.....	3·6	.....	Moth emerged; weight of moth.

An examination of the two tables of weights shows that the larva eats more as it grows and simply gorges itself with food before it pupates or enters upon the period of rest. Before each moult it abstains from food for some time and its weight is seen to actually diminish in some cases. This diminution of weight is specially evident before the last moult; the weights of both the larvæ diminished from about 18 to about 8 grains in the course of 48 hours. The pupa weighs less and the moth still less.

Both of the larvæ which were weighed attained to a maximum weight of about 18·5 grains. One of them ate about 35 grains and the other about 33 grains of green gram leaves. The average weight of a larva, which has fed in favourable circumstances in the fields, has been found to be about 20 grains. The amount of food eaten by a larva of *Agrotis ypsilon* may, therefore, be taken to be approximately 35 grains. If each female moth lays about 350 eggs, the larvæ hatched out of them destroy about $1\frac{3}{4}$ pounds of green leaves. The damage actually done, however, is considerably greater as the larvæ are in the habit of cutting down the whole plants. As the cutworm larvæ live underground, they are far less liable to be destroyed by parasites than caterpillars which live on their food-plants. But their habit of killing and eating each other results in the destruction

of a large number. When there is an insufficient supply of food, small and weak ones are devoured in lots by bigger ones ; but one will kill and eat another as big as itself. Resting larvæ and pupæ in the early stage are liable to be eaten up whenever met with, because in these cases there is no resistance at all. They are seen to eat each other with relish in presence of abundant food. It is interesting to confine some larvæ in a small space and watch their behaviour after some time when they become hungry. Each takes a bite at any one it comes across and the victim to such bites is turned into food. When too much disturbed, the larva bites at its own body.

The larval stage is about one month, being a few days more in winter and several days less in hot summer. Below are shown the larval stages of three lots.

Larvæ hatched.	Larvæ pupated.	Duration in days.
6th February	11th to 14th March	33—36
12th March	8th to 11th April	27—30
21st ,, ...	17th April	27

The underground life of the cutworm larvæ suggested the idea of finding out their behaviour in water. The small larvæ, a few days old, coil up and come to the surface of the water. They remain floating for some time, and the whole lot may be carried away by a flowing current. Older and developed larvæ come out of their holes when water is poured in : and when under water they are entirely helpless and cannot avail themselves of even any rough support which may fall in their way in their struggling movements. After struggling for about 15 minutes almost all of them become paralysed and lie as if dead at the bottom. Only in a very few cases, specially among young ones, the larvæ may not be paralysed and also can get upon any support that presents itself. But generally in such cases they remain half floating. One half-grown larva kept floating for 18 hours but died. They may revive when taken out of water, after varying periods of submergence, but long periods of submergence ensure the death of many ; and although they may show signs of life after being

taken out of water, they cannot, in most cases, pupate successfully. The following is the result obtained in several cases.

Number of larvæ.	Submerged for how many hours.	Revived.	Died.
10	3 hours.	8	2
10	5 ,,	7	3
5	8 ,,	1	4
14	20 ,,	3	11

In the third case one remained floating all the time: but it died while a paralysed one revived. The above was corroborated by the following experiment without the larvæ being actually placed in water. More than one hundred larvæ hatched on a gram plant in a flower-pot. They were left in the pot and supplied with sufficient food. The pot was placed in a dish containing water which was less than one inch and sometimes half an inch deep. When the larvæ were about 15 to 20 mm. long, they tried at night to escape from the pot, and in so doing fell into the water in the dish and died in lots of 12 to 30. Only four larvæ survived, one by remaining in the pot and three by making good their escape out of the water.

Pupa.—The larva pupates underground. In the insectary many prepared chambers of earth within which they pupated. Before pupation the larva rests for one to three days. The resting period is shorter in hot and longer in cold weather. It is still longer when it bears the maggot of a Tachina fly inside its body. When resting it shortens longitudinally, the segments of the body become well marked, and the form becomes tapering, slightly towards the head but more prominently towards the hind end. Then the upper side of the head and thorax bursts longitudinally, and the soft yellowish white chrysalis comes out by a sort of wriggling movement. In the course of about 12 hours the chrysalis hardens and becomes red-brown in colour. It is about 20 mm. long and is of the Noctuid type. The abdomen is segmented, the segments telescoping into each other and thus being capable of wriggling movements which can cause a change of position. This end is pointed, and bears small

needle-like processes. The head end is obtuse. In the advanced stage of the pupa the black eyes become prominently noticeable and the wings folded on the ventral side can be marked.

The pupal stage varies from about 10 days in summer to about 30 days in winter. The following table gives the pupal stage, together with the resting period of some which were specially noticed :—

Number of larvæ.	Began resting	Pupa.	Moth emerged	Duration.	
1		4th November.	22nd November.	18 days.	
1	26th January.	29th January.	26th February.	28 ,,	
1		,, ,,	1st March.	31 ,,	
2		9th February.	11th ,,	30 ,,	
1	7th February.	10th ,,	12th ,,	30 ,,	
1	10th ,,	12th ,,	,, ,,	28 ,,	
1		8th April.	18th April.	10 ,,	Submerged for 8 hours on the 16th April.
2		,, ,,	19th ,,	11 ,,	
1	9th April.	10th ,,	22nd ,,	12 ,,	
1	10th ,,	11th ,,	,, ,,	11 ,,	

The caterpillars do not hibernate, but are seen to be most active in winter. Their pupal stage is longer, however, in this season. Below are given some data which prove that they do not hibernate :—

Larvæ collected	Moths began to emerge
30th October 1905.	22nd November 1905.
21st November ,,	6th January ,,
1st December ,,	21st January 1906.
4th ,, ,,	13th January ,,
19th ,, ,,	2nd February ,,

The effect of short submergence on the resting larva and pupa is not so injurious. After eight hours' submergence, four out of five resting larvæ successfully pupated ; and moths emerged out of two pupæ which had been kept under water for eight hours. But five pupæ kept from the second day in watery mud rotted completely after eight days. The effect of hot sun is destructive to both. All of five resting larvæ and five pupæ, kept on the surface of the ground exposed to the sun in April, shrivelled up and began to dry within two days.

Imago.—Moths generally emerge at night, but in the insectary a few were noticed to emerge during the day. The obtuse end of the chrysalis bursts open and the moth creeps out of the case, with soft and crumpled wings, which, however, expand and harden very soon. The moth measures about one inch from the head to the tip of the forewings and has a wing-expanse of about two inches. When it rests, the forewings wholly cover the body, their inner or anal parts overlapping each other on the back. The sides of the wings curve downwards. The moth looks dark or blackish with some greyish patches on the back. Its habits have been noticed above. Ordinary light has no attraction for the moths. They may show a slight restlessness at the first sight of it, but they drank food and also laid eggs while the lamp was burning at a distance of about half a yard. The moths pair end to end. The interval between the emergence of the moth and the commencement of oviposition was marked in the case of only one moth. It began to lay eggs on the fourth day after emergence.

The duration of life of the moths is shown below ; males die sooner than females.

Number of moths.	When emerged.	How fed.	When died.	Duration.
3	9th January.	Kept without food.	1 on 13th. 1 on 14th. 1 on 16th.	4 to 7 days.
3	12th March.	Fed with sugared water daily.	1 on 16th. 1 on 17th. 1 on 26th.	4 to 14 days.

Occurrence as a Pest.

It has been sent in as a pest during the past three years on only a few occasions. It was reported from Monghyr as attacking opium and gram in January 1906, and at the same time from Nilgeshmari, Assam, as attacking tobacco and potato. Rungpur Farm (Bengal) experienced an attack in November 1905, and it was sent in from flooded land in Mokameh, Patna district, in December 1905. It has been sent in from Patna as attacking potato in March 1907. There are many references to this pest

in Indian Museum Notes under the name *Suffusa*. They may be tabulated as follows :—

Vol. I.	p. 33.	Jessore, feeding on	...	...	Mustard, linseed.
„	p. 103.	Kurseong „	...	...	Potato.
„ II.	p. 6.	Oudh „	...	...	Poppy
„		Ghazipur „	...	...	„
„		Fatehgarh „	...	...	„
„ II.	p. 161.	Murshidabad „	...	...	Wheat.
„		Tipperah „	...	...	Barley, gram, oats, peas.
„		Patna „	...	...	*Lathyrus sativus.*
„ IV.	p. 62.	Kashmir „	...	...	Hops.
„ V.	p. 184.	Shahabad „	...	...	Poppy.

As the life-history is fully dealt with above, it is unnecessary to quote from these sources. I have been unable to find any other original references to this insect in India, and no definite study of it appears to have been made. (For a successful method of treatment, see Agricultural Journal of India, Vol. II, p. 43.)

A curious feature of the insect is its occurrence in lands that have been flooded during the previous kharif season. This has been observed and has also been reported by district officers. Whether it is due to the growth of a crop of weeds on such lands, among which the larva normally lives, or due to the greater amount of moisture in the soil cannot be determined; having regard, however, to its normal habitat in waste land grown with weeds, the moth may always select such land for oviposition, and ploughing of the weedy land does not eradicate the larvæ, large full fed larvæ having been found in Pusa fields that had been ploughed and sown. This is one of the smaller class of insects which are active and breed freely throughout the cold weather in localities at a less elevation than 2,500 ft. Its activities as a pest are confined to about four months from December to March; this may not mean that these are the months when it is really most abundant, though this may prove to be so, but the explanation may be that during those months it is found in the young crops sown in lands where the moisture is greatest, whereas after the winter crops are reaped and the rains come, it is scattered over weedy

waste lands and not seen. It is not clear why the moths should be so rarely captured from June to October, but there is at present no reason to believe that the breeding is confined to the cold weather, as at first sight appeared to be the case. The fact that moths were caught in September and full-grown larvæ early in October shows that it is active in the wet months. It has been found as a pest in irrigated lucerne up to the end of May. As a pest, however, it is found almost wholly in the cold weather, and the moth-collector will, I believe, get moths most frequently then. Meyrick (Handbook of Lepidoptera) gives May to July as the months for the larva in England, August to April for the time during which the imago is found. This may be compared with the behaviour in England of *A. segetis*, Schiff, and with the behaviour of *A. flammatra* in India. It is of course a totally different history to that of the individuals recorded in India.

EXPLANATION OF PLATE XIV.

Figs. 1-8. *Agrotis ypsilon* Rott.

Fig. 1. Egg much magnified.
„ 2. Young caterpillar, magnified.
„ 3. Older caterpillar, magnified.
„ 4. The same in the natural curled attitude.
„ 5. The second and third abdominal segments, magnified
„ 6. Chrysalis, magnified
„ 7. Moth, wings expanded.
„ 8. Moth, resting attitude.
„ 9. *Agrotis flammatra*, Schiff.
„ 10. *Euxoa spinifera*, Schiff.
„ 11. *Euxoa segetis*, Hubn. (The colouring is too red

PLATE XIV.

1

2

3

4

5

6

7

8

9

10

11

THE INDIAN SURFACE CATERPILLARS.

Engraved and Printed by the Calcutta Photolyp